A further insight into the potential of bistatic SAR in monitoring the earth surface

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***Abstract* - This contribution discusses some relevant features of bistatic scattering from vegetation, based on a simulation analysis using a theoretical model developed at Tor Vergata. This paper is focused on land cover monitoring by a combination of monostatic and bistatic radar. The main mechanisms contributing to bistatic scattering are highlighted and its exploitation in monitoring vegetation covered surfaces is discussed.**

I. INTRODUCTION

Bistatic SAR systems have been recently the subject of several studies mainly concerned with the space mission design [1], [2], but less attention has been given to the potential of the bistatic technique in monitoring the earth surface.

The mechanisms which contribute to the bistatic scattering from a plane surface covered by vegetation are here analysed by using the theoretical computational approach developed at Tor Vergata University. Models of agricultural crops are considered in our simulations, and the various contributions originating from the canopy components and the underlying soil are looked into details. The specular coherent reflection appears generally to be the dominant component of the bistatic scattering process, and the bistatic radar response carries the imprinting of the vegetation parameters essentially through the attenuation introduced by the covering canopy. Our simulation analysis shows that, consequently, an enhancement of sensitivity to features of the underlying soil occurs with respect to the monostatic case.

Since the main scattering effects in the monostatic and bistatic SAR geometries are different, by joining monostatic and bistatic observations the information content can be augmented. In particular, an improvement in soil moisture retrieval is expected by using such a joint data set. Our simulations refer to possible combinations of (passive) SAR receivers with spaceborne SAR system, such as ENVISAT, which have multi-polarization and multi-resolution capabilities. The expected performance in non-specular configurations is also considered, and the effect of a variable spatial resolution is also examined.

II. THEORETICAL RESULTS

The Tor Vergata model [3], [4] is able to describe the electromagnetic properties of vegetated canopies over a rough soil considering a great number of morphological parameters. This allows to simulate both the backscattering and specular scattering coefficient of different agricultural species, taking also into account their growth state. In this work, sunflower and corn crops have been considered. For both canopies a two-layer structure has been selected:

- The top layer contains dielectric discs which represent leaves,
- the bottom layer contains vertical cylinders over a rough surface, representing stems over soil.

Variation of vegetation parameters have been simulated according to ground data collected during several past campaign [4].

In our previous works, [5], [6], we studied the dependence of the specular scattering coefficient on the plant biomass, and we observed that, unlike the backscattering coefficient, it is not affected by the saturation problem, and that it shows an enhanced sensitivity to PWC. Our simulation analysis indicates that the enhancement of sensitivity with respect to the monostatic radar case is essentially due to the specular coherent reflection from the soil, which is only attenuated by the overlying vegetation, and it appears to be the dominant component in the scattering process.

Now we investigate the sensitivity of specular scattering coefficient to soil parameters. In this study the soil moisture content has been varied between 5% and 25%. Results are shown in fig. 1, where the theoretical specular scattering coefficient at HH polarization is reported with the corresponding simulation of the HV backscattering coefficient at C-band. At this frequency, the sensitivity of the backscattering coefficient to the soil parameters is reduced by the overlying vegetation, especially when it is dense or thick. Our simulations of the specular scattering coefficient indicate an enhancement of sensitivity to the soil condition with respect to the monostatic case. The high scattering in the specular direction is dominated by the coherent component, which increases with increasing soil moisture

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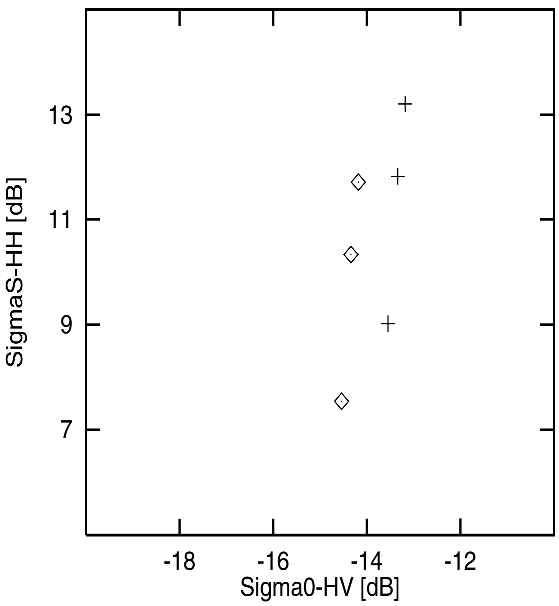

Figure 1: HH polarized specular scattering coefficient vs HV polarized backscattering coefficient, for variable soil moisture content ($0.5 < m_g < .25$). $f = 5.3GHz$, $\theta = 25°$. Crosses=Sunflower crop with PWC=3.5 kg/m^2, Diamonds=Corn crop with PWC=3.5 kg/m^2,

content, and this trend is only reduced by the presence of vegetation, but not cancelled.

The design of a bistatic mission must deal with the problem of the spacecraft safety. For this reason, configurations with non-specular bistatic angle have also been proposed. However, it must be borne in mind that, depending on the radar parameters and on the physical properties of the observed surface, the contribution coming from soil coherent scattering can be lost when the observation angle departs from specularity. In fig. 2, the bistatic scattering coefficient of a corn crop with PWC=4 kg/m^2 is reported in a polar diagram (at 5.3 GHz and for a pixel size of 30mx30m). It is shown that the bistatic scattering coefficient gets comparable to the backscattering one, even for observation angles very close to the specular angle. Analogous results are also obtained when the observation plane does not coincide with the incidence plane.

III. Conclusions

The possibility of performing bistatic measurements is getting closer and closer. Such a radar configuration gives added value to monostatic measurements: our results show that a better sensitivity to soil parameters can be achieved. However, particular attention to the bistatic configuration design must be given: from our theoretical simulations it appears that the observation angle must be chosen with care, in order to fully exploit the information content of coherent scattering.

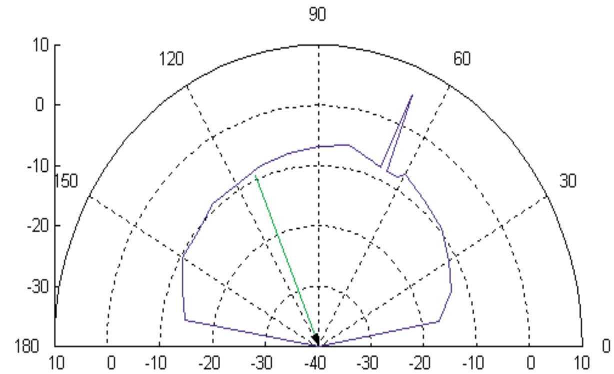

Figure 2: VV polarized bistatic scattering coefficient of corn crop with PWC=$4kg/m^2$. $f = 5.3GHz, \theta = 25°$

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